Design of an Electrical Fire Monitoring and Warning System Based on Transducers

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Abstract

An electrical fire monitoring and warning system based on transducers is designed. The system consists of SCM, drain current detecting circuit, smog detecting circuit and temperature detecting circuit. Electric isolation and protection of the important components in general electrical environment are also designed. Experiments show that, when abnormal temperature, drain current, or smoke happens, the system can carry out data collection, aggregation, comparison, analysis and alarm, achieving the function of automatic monitoring and warning of electrical fire.

Keywords

Transducer; Electrical Fire; Drain Current; Monitoring; Automatic Warning

Page Style

The Introduction

Electrical fire generally refers to those fire which are caused by electrical wiring, electrical equipment, appliances and power supply equipment failure to release heat (such as high temperature, electric arc and spark), and the energy release not under the failure condition (such as the hot surface of the electrothermal apparatus) spontaneous combustion in capable ignition or the fire caused by other fuel, it also including the fire caused by lightning and static electricity.

From the point of origin, electrical fires mainly includes the following four aspects: first, the fire caused by the leakage; Second, the fire caused by short circuit; Third, the fire caused by overload; fourthly, the fire caused by the contact resistance is too large fires [1] .In these aspects, the leakage fire appears the most. The fire caused by the leakage was due to a point on the transmission lines which was caused by man-made or natural causes and led to a decline in insulating ability, it causes electric current flows between the conductor and the wire or between the conductor and the ground, local part will get hot and high temperature will happens when encounter greater resistance, it will also light the tinder nearby and causes a fire. Moreover , sparks in the leakage place will also become a major hidden danger of electrical fires [2]. Many fires are caused by short circuit which was caused by circuit aging, if could test the leakage current earlier,it could provide the staff enough time to escape from hazards and reduce casualties and even can completely avoid the happening of the fire.

The traditional fire alarm only contains smoke sensor, its main function is to test the smoke or gas come from the burning of fuel[3,4,5]. The basic principle of work is using the smoke sensor to detect the concentration of the smoke or gas,connect the smog sensor to the amplifier circuit, the system will generate alarm signal when the signal is greater than the threshold. In order to prevent false alarm triggered by dust, usually，the system won't send out alarm signal until smoke concentration in air becomes very large, that is to say, the signal alarm is sent out when the ignition has been produced and the fire has spread already.So when it is told that there is a fire occurs, the easiest way to put out fire has been delayed. The fire spread around quickly, it is hard for the people to escape from the fire, besides, some of the fuel would produces a lot of poisonous gases at the same time ,as long as people inhaled few of that will appear poisoning phenomenon, it increases the difficulty in escaping from the fire. Due to the deficiency of traditional fire alarm on the alarm time, it will lost the best time to escape, made heaviey loss of the personal safety and very bad social impact.

This paper designed a electrical fire monitoring and early warning system,the system has a characteristics of monitoring leakage current,and it belongs to the early forecasting warning system. Through to monitor the leakage current in the line, can effectively confirm

whether the line of leakage current is too large, and could early find the hidden trouble that could lead to a fire, the system can discover and eliminate hidden dangers before ignition occurs. Unlike traditional automatic fire alarm system, the traditional fire alarm system is to reduce the loss, however, the electric fire monitoring system of early warning could avoid the loss.

The Overall Structure of the Monitoring and Early Warning System

As single-chip microcomputer monitoring and early warning system has completely controled the smoke detection circuit, leakage current detection circuit and temperature detection circuit already; implementation of smoke concentration, the value of the leakage current and temperature for testing, and introduced into SCM; single-chip integrated the incoming data,and send out alarm signal. The overall structure of the system is shown in figure 1.

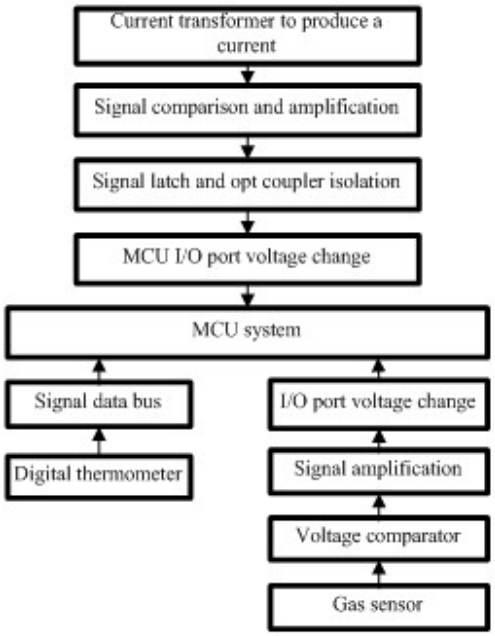

FIG.1 OVERALL STRUCTURE DIAGRAM OF SYSTEM

The Design of The Hardware of a Monitoring and Early Warning System

The Design of Hardware in SCM System

Singlechip computer system is the core of the hardware part of the control module in the electrical fire monitoring system, its main function is to control the smoke detection circuits , the leakage current detection circuit and the working of the temperature detection circuit, collect the data that detected by the detection , put these data into the comparison and analysis, to determine whether to send out alarm signal. The design selects the PIC16F877A single-chip as the core, including the reset circuit, crystals circuit, voltage conversion circuit and the interface circuit which is connected with the emulator. Choose MC7805 as the voltage conversion circuit chip and matched with corresponding capacitance, so that we can convert the dc voltage from 12 v to 5 v for the use of SCM work. The internal ROM and RAM of the singlechip are chosen PIC16F877A The interface circuit which is connected to the emulator is to link the reset of the MCU,the power supply, and the pin of RB6 and RB7,put the pins into a column in other parts of the circuit board, the data line can be inserted on the row needle, the emulator could be connected to a circuit board through the data line.The design of the single-chip system is shown in figure 2.

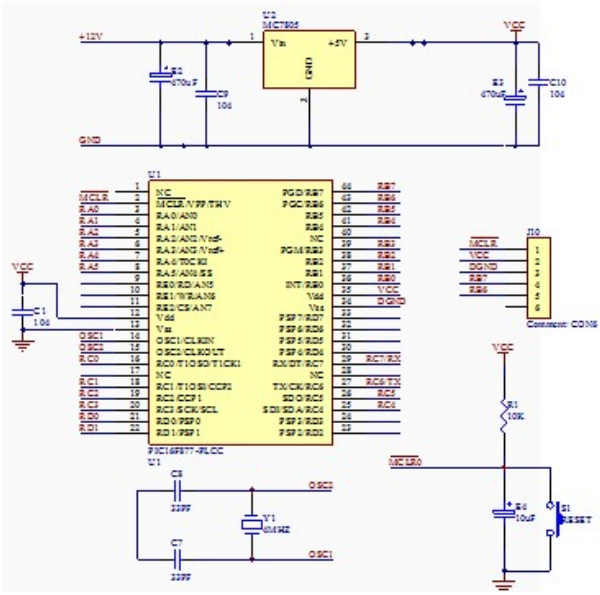

FIG.2 DESIGN OF SCM SYSTEM

The Design of The Hardware of the Test System

1) The design of the Smoke Detection Circuit

Smoke detection circuit selects the MQ-2 in the gas sensor. MQ-2 for the liquefied petroleum gas, propane, hydrogen and the carbon monoxide has a high sensitivity[6], the detection of natural gas and other combustible vapor has very good effect, in a wide range of concentrations ,it also has a good sensitivity to combustible gases. MQ-2 has 6 pins, two of the pins connected to the heating circuit, the heating circuit adopts 5 v power supply, 31 Ω heat resistance, it will begin to work after heating for 30 seconds. The other four pins are responsible for

taking out the signal, provisions of the working voltage of is 12 v. According to the resistance of the MQ-2 would fall as the concentration of carbon monoxide increases,so we can design a simple voltage comparison circuit. The op-amp of the voltage comparison circuit selects the true differential input of the operational amplifier LM324 with four levels, it could work as low as 3.0 v or higher to 32 v power supply under the mode of single power supply, this design uses the working voltage of 12 v.

2) The Design of the Circuit Which is Using for Detecting Leakage Current

The circuit which is using for detecting leakage current selects zero sequence current transformer. Zero sequence current transformer is a kind of current transformer in which there is single turn to wear heart type ,and it commonly used in electric power protection equipment. The basic principle of its operation is based on the kirchhoff's current law: all the current flows into any node in the circuit add up to equal to zero. Under the normal working condition of the wiring and electrical equipment, the vector of each phase current and should be equal to zero, so the secondary side winding of the zero sequence current transformer with no signal output. When the ground fault occurs, the phase current vector and is not equals to zero, fault current makes the zero sequence current transformer toroidal core of the magnetic flux, secondary side of the zero sequence current transformer induced voltage signal, and it can drive other components for the next action [7]. Zero sequence current transformer is made of the permalloy, generally divided into two kinds, one kind is the permalloy chips which is thickness of 0.2-0.3 mm, inner diameter is 13 mm, folded after processing by 8-10 pieces would as thickness as3 mm thick rings.Another kind forms by using permalloy strip winding , after forming ring with the first basic same, permeability can be 5T- 6T. Select VG54123 chips as the zero sequence current transformer voltage generated in the testing and when the voltage is higher than threshold alarm signal will be produced. Owing to the voltage of VG54123 is 12 v while the voltage of MCU is 5 v, in order to put the signal of level change into the single-chip and protect the microcomputer from being burned owing to the high voltage, to prevent the input signal from disturbing by other signals, put optocoupler into light leakage current detection circuit and single-chip for electrical isolation. When the leakage protector working in the field of strong electric and magnetic environment, often suffer from all kinds of interference,and the interference will affect the working of leakage protector in various ways. If leakage current reaches or exceeds the threshold without the police, can cause a serious fire hazard, followed by the cause of ignition and the fire spread quickly, finally cause a fire. The fire could be avoided, but happened for the cause of the strong interference of the leakage current protector did not achieve its proper role. If leakage current does not meet the threshold for the interference lead to wrong alarm signal, line power supply is disconnected,cause the on duty staff mistake leakage current is greater than the threshold and repeated check on leakage current, after closing line again, it takes a lot of manpower and material resources. If multiple cause of alarm signal, the alarm will be artificially outage, it increased the hidden danger of fire, when leakage current really is greater than the threshold ,the fire alarm will stop and it would cause a significant security hidden danger, therefore, leakage alarm circuit with strong anti-interference performance is of great necessity. The scale of the integral capacitor which is linked with foot 4, will directly influence the anti-interference performance of leakage current alarm circuit, at a time VG54123 link with integral capacitor constantly for about 5 ms, it is of highly advantageous to suppress the sharp narrow interference pulse. Although the inhibition ability as the capacitance increase of increased, but in the choice of capacitance, the action time and triggering sensitivity should also be taken into consideration, usually ,select the capacitor from 0.033 uF to 0.069 uF, here we choose capacitance of 0.047 uF, and select the capacitance of small loss under normal working state. A 0.047 uF capacitor should be installed between ground 1 and the foot to enhance anti-jamming ability and the foot 6 feet 7 foot 1 also Due to the VG54123 have the function of the lock,once the lock circuit enter in locked state,it would be unable for device to liberate, unless the leakage switch received the leakage signal and the power will be immediately cut off, the locking circuit will automatically release as well .

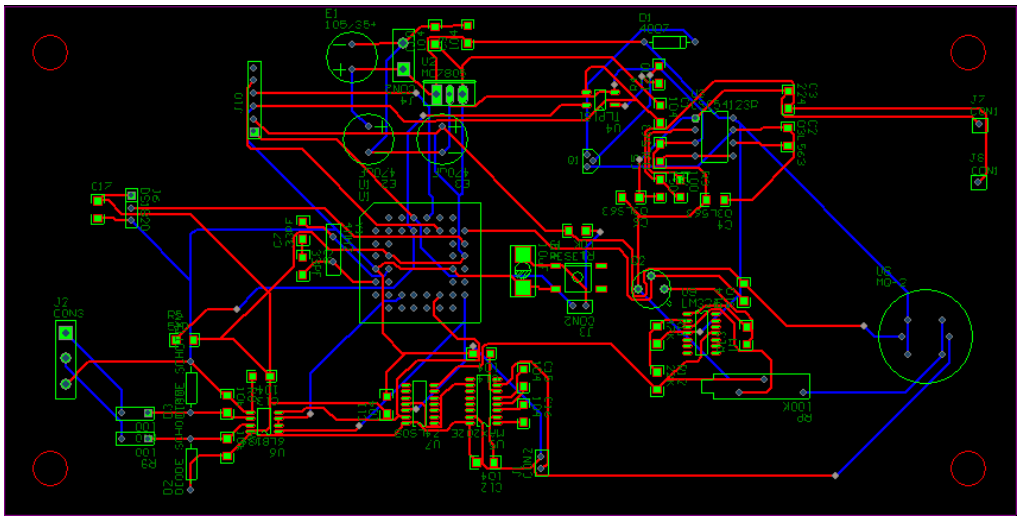

FIG.3 PCB DESIGN OF DETECTING SYSTEM

3) *The Design of Temperature Detection Circuit*

Choose chip DS1820 as the components of the temperature detection circuit. The oscillation of frequency crystal vibration in the DS1820 which is of low temperature coefficient receives little influence by temperature [8,9], and used to generate pulse signal with fixed frequency sent to the down counter A, but the oscillation frequency of the high temperature coefficient of crystals changes with the temperature change is obvious,put the signal gotten above as the input of the down counter B. In addition， DS1820 contains a counter, when the counter opens, DS1820 count the pulse which is produced by low temperature coefficient of oscillator,after the above the process of temperature measurement is finished. Open time of the counter is determined by the high temperature coefficient of oscillator counter. Every time before the measurement, put the count which is corresponds to -55 ℃ into the down counter register A and temperature register, the down counter register A and temperature register will be preset at the base value which is corresponds to -55 ℃. Down counter A for the pulse signal which is produced by the low temperature coefficient of crystal subtraction counting , when the preset value of down counter A reduced to 0, the values of temperature register will plus 1, the preset number of down counter 1 will be loaded again, down counter A start again to count the pulse signal that produced by the low temperature coefficient of crystals, perform this loop until down counter B counts to zero,then stop accumulating the values in temperature register, at this time the temperature in the register values is the measured temperature value The slope accumulator in DS1820 can be used for compensation and correction of temperature measurement in the process of nonlinear [10], and its output is used to fix the preset value of the down counter, as long as the counter is not closed, just repeat the above process until the temperature values in temperature registers is as high as the measured temperature value.

Detection systems which named PCB was designed as shown in figure 3.

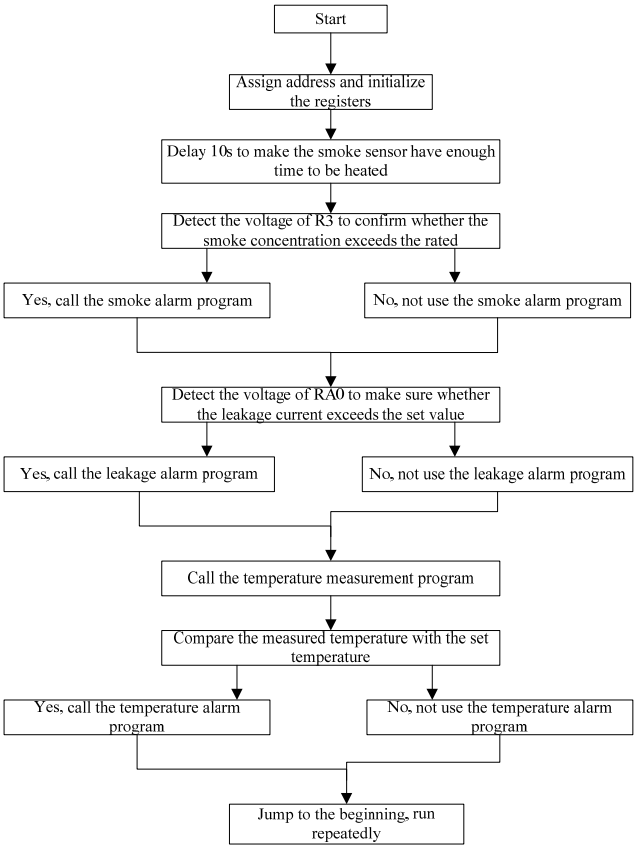

FIG.4 FLOW CHART OF MAIN ROUTINE

The Software Design of Monitoring and Early Warning System

Loop testing through RB3 and RA0 , to confirm whether the smoke concentration exceed the rated value, leakage current exceed the rated value, by comparing temperature measured from the DS1820 temperature and temperature thresholds can be used

to confirmed whether the environment temperature is higher than the temperature threshold. When there is a smoke concentration exceed the rated value , the leakage current exceeds the rated value,besides the environment temperature also exceeds rated value ,the system will generate alarm respectively.The working process of the main program is shown in figure 4. Length place is restricted, so the subroutine design process not described here.

Conclusions

On the basis of the traditional fire alarm system ,in view of the current frequent electrical fire situation, so designed the electrical fire automatic monitoring and early warning system that the system refers to electric fire characteristic,which was used the combination of sensor and MCU.The system also applies to the fire which isn't caused by the electrical. The design of the hardware and software in the system has be carried on thorough discussion, the electrical fire can be early warned by detecting leakage current, assisted with smoke and temperature detection circuit, can also be able to monitor the electrical fire. The experimental results show that the collected data and actual data are consistent, stable operation, low power consumption, low cost,so the experiment have certain practical and promotional value.

REFERENCES

Chen Libing，Fan Yujin，Dai Jie. "'Design of Temperature Acquisition System Based on AT89S52 Single-chip." Machinery & Electronic, 2011(2).

Fu Qiang. "'The causes and prevention of electrical fire." Journal of theory, 2012 (4) : 33-34.

Liu Qingping. ",Research of Fire Alarm System." Science Mosaic, 2011(7).

Wang Jin, Chen Xia, Rui Guohon. "Asynchronous motor fault protection application and research in coal winning machine." Industrial automation, 2010 (7) : 79-82.

Wei Jungan，Zhan Chao，Tian Jianxue. "Application in the Temperature Measure System." Instrumentation Technology, 2008(8).

Wu Hongtai. "Seamless rail temperature automatic monitoring system based on single chip microcomputer research" Beijing: Beijing jiaotong university, 2008.

Ye Lina. "'My opinion about the management electrical device in coal mine." Strait science, 2010(9).

Yu Hongbo,， LI Hui. ", Design and Implementation of Portable GSM Wireless Gas Warning System." . Control and Instruments in Chemical Industry, 2011，38(11).

Zhang He. ''Multichannel Wireless Fire Alarm System." Modern Electronics Technique, 2007，30(5).

Zhao Hailan Zhao Xiangwei. "The principle and application of the intelligent temperature sensor DS18B20." Modern electronic technology, 2003 (14) : 32-34.

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